REMARKS

This Reply is in response to the non-final Office Action mailed September 27, 2005 and is accompanied by a petition to revive the present application abandoned on December 27, 2005 by the previous Assignee, the U.S. Department of Energy. One of the named Inventors, Rusi Taleyarkhan, has recently obtained all rights to the present application, and has picked up the prosecution of the present case.

Inventor Taleyarkhan has invested substantial time and money into the prosecution of the present case due to significant value perceived for the present invention. As described below, testing of the present invention subsequent to the filing thereof, reported in highly respected publications by both Inventor Taleyarkhan as well as independent third parties, has demonstrated beyond any measurable doubt that the thermonuclear fusion evidence reported in the present application is not only both theoretical possible, but thermonuclear fusion according to the present invention based on the present application as filed may be practiced by those having ordinary skill in the art without undue experimentation.

Claims 22-25 and 27-33 were pending at the time of the Office Action. All claims were rejected based on:

Rejections based on non-art grounds:

Section 4: 35 USC 112, paragraph 1 (failing to provide an enabling disclosure);

Section 5: 35 USC 101 ("inoperative and therefore lacking utility");

Section 6: 35 USC 112, first paragraph (one skilled in the art not enabled to make and use the invention; "same as the reasons set forth above in Section 4");

Section 7: 35 USC 112, second paragraph, claim 22 indefinite based on term "portion";

Rejections based on cited art grounds:

Section 8: claims rejected based on US Pat. No. 5,659,173 to Putterman or US Pat. No. 4,333,796 to Flynn.

In this Reply, claims 22-25 and 27-33 have been cancelled. New independent claim 34 is based on former independent claim 22, new claim 35 is based on former claim 23, new claim 36 is based on former claim 25; new claim 39 is based on former claim 27, new claim 40 is based on former claim 28, new claim 41 is based on former claim 29, new claim 42 is based on former claims 31 and 32, and new claim 43 is based on former claim 33. New claim 37 relating to a time varying pressure state is characteristic of an acoustical field, new claim 38 relating to a constant tension state is characteristic state when using the disclosed centrifugal source. No new matter has been added.

The Abstract which had been objected to has been amended to now be consistent with the restriction election to process claims. Accordingly, the objection to the Abstract is overcome.

Before reviewing the claims rejections, Applicants will first review the claimed invention as recited in new claim 34:

34. (New) A thermonuclear method for producing nuclear fusion, comprising the steps of:

providing a working liquid enriched with isotopic D or T atom comprising molecules;

degassing said liquid to reduce a dissolved gas content therein, wherein said dissolved gas is removed using an applied vacuum;

placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid, said tension state imparting stored mechanical energy into said liquid portion;

directing fundamental particles at said liquid portion when said liquid portion is in said tension state, said fundamental particles having sufficient energy for nucleating a plurality of bubbles from said liquid, said bubbles having an as nucleated bubble radius greater than a critical bubble radius of said liquid;

growing said bubbles; and

imploding said bubbles, wherein a resulting temperature obtained from energy released from said implosion is sufficient to induce a nuclear fusion reaction of said isotopic D or T atom comprising molecules in said liquid portion.

As now recited, the "working liquid [is] enriched with isotopic D or T atom comprising molecules". Support for this limitation can be found through the present specification, such as page 7 of the summary which recites " The working liquid preferably includes an enriched deuterium or tritium containing liquid. For example, deuterated acetone may be used". Acetone is an example of an organic liquid.

Claim 34 now recites degassing the working liquid to reduce a dissolved gas content therein, using an applied vacuum. Degassing is recited in original claim 24 and is described throughout Applicants' specification to remove dissolved gases in the working liquid as much as possible, such that any remaining dissolved gas in the liquid does not

emanate during tensioning of said liquid unless energetic fundamental particles are directed, as noted on page 16 of Applicants' specification. "The SL intensity can also be increased by increasing the rate of collapse of the imploding bubble. The rate of bubble collapse can be made more abrupt through more intense shock generation as compared to previous approaches and by a reduction in the amount of gas dissolved gas in the working liquid, which can otherwise result in gas cushioning". A vacuum pump shown in Fig. 1 as vacuum pump 120 which provides removal of dissolved gases. Removal of gasses by the claimed degassing allows the bubbles subsequently generated by the claimed fundamental particles to be 100%, or nearly 100% vapor filled from the working fluid itself.

At least a portion of the liquid is placed into a tension state, a maximum tension in the tension state being below the cavitation threshold of the liquid. Being below the cavitation threshold, the working liquid does not nucleate bubbles at this juncture in the process. At least a "portion" simply and clearly refers to the fact that the entire liquid volume may not be in the tension state at a given time. For example, an acoustical tensioning source will generate a generally sinusoidal pattern throughout the working liquid, with alternating regions of compression and tension, such as a sinusoidal pattern. The tension state thus imparts stored mechanical energy into the liquid portion.

Fundamental particles (e.g. neutrons from a neutron source) are directed at the liquid portion when the liquid portion is in the tension state. "Fundamental particles" are well known in the art to be particles which make up the nuclei of all atoms, and therefore of all chemical elements. Protons are positively charged particles and neutrons are uncharged particles. Alpha particles are the nuclei of helium, the next element heavier

than hydrogen, and consist of two protons and two neutrons. Such energetic fundamental particles having sufficient energy for nucleating a plurality of bubbles from the liquid, which is known to be on the order of at least 10^6 eV. Support for fundamental particles having sufficient energy can be found throughout Applicant's specification and claims as filed, and support for the plurality of bubbles can be found throughout Applicants' specification, such on page 47 which discloses " Figure 6(b) shows various stages in bubble growth using a centrifugal based fusion system. Once the desired level of negative pressure and cavitation energy (e.g. neutrons) is provided sufficient to cause nucleation, single or multiple bubble cavities can be nucleated as depicted by a symbol identified with reference 655". Moreover, regarding multiple bubbles, page 26 recites "When multiple bubbles are present, the situation can become more complex with considerable wave energy scattering, that can make the microphone signals noisy and difficult to interpret".

The bubbles have a bubble radius greater than a critical bubble radius of the liquid, and thus are stable bubbles, thus being able to grow and are grown in the claimed process, such as under the influence of an acoustic field which provides intervals of tensioning. The recited fundamental particles are energetic particles such as the alpha particles, neutrons and fission fragments described throughout Applicants' specification, and now claimed in new claim 44.

The bubbles are then imploded, wherein a resulting temperature obtained from energy released from said implosion is sufficient to induce a nuclear fusion reaction of said isotopic D or T atom comprising molecules in the liquid portion.

New claim 43 recites "Wherein said liquid is an organic liquid". Organic liquids are described throughout Applicants' specification, such as above table 1 on page 29. New claim 41 recites "wherein said plurality of bubbles as nucleated have a size of 10-100 nm". Support for this limitation can be found on page 17 and 39, first full paragraph. Accordingly, no new matter has been added.

Regarding non-art rejections

The core of the Examiner's non-art rejections in Sections 4-6 of the Office Action relate to disbelief regarding the operability of the present claimed invention to produce nuclear fusion, based in large part upon published articles from skeptics/naysayers. Some of the Examiner's identified skeptics/naysayers now acknowledge the operability of the present invention. Moreover, the publications and art cited by the Examiner was well prior to 2002 where the worldwide thrusts were basically to study the sonoluminescence (SL) phenomenon and the possibility to attain thermonuclear fusion using the so-called single-bubble sonoluminescence (SBSL) approach where a single gas-filled bubble that is levitated in a sound field and then made to oscillate continuously and periodically in a sound field. These systems are now known (see for ref. Crum, 1997; citation below) to have inherent limitations preventing the attainment of conditions necessary for attaining thermonuclear fusion, which why the present Inventors deliberately chose a radically different approach. As described below, the present claimed invention produces nuclear fusion when practiced according to the present claimed invention in conjunction wit teachings in the related specification.

In the discussion to follow, the following references will be discussed (copies provided herewith, except Crum 1997, Didenko 2002, Gross (a book), and Nigmatulin 2004), which will be forthcoming shortly, likely within three (3) weeks of this filing.

References Cited (Not intended to be an IDS):

- Camara, C., S. Putterman and E. Kirilov, "Sonoluminescence from a single bubble driven at one megahertz," Phys. Rev. Lett. 92, 1243 (2004).
- Crum, L., and T. Matula, "Shocking revelations," Science **276**, 1348 (1997).
- Crum, L., "Sonoluminescence and Acoustic Inertial Confinement Fusion," 5th Int. Symposium on Cavitation," Osaka, Japan, Nov., 2003.
- Didenko, Y. T., and K.S. Suslick, "The energy efficiency of formation of photons, radicals and ions during single-bubble cavitation," Nature **418**, 394 (2002).
- Forringer, E., D. Robbins, and J. Martin, "Confirmation of Neutron Production During self-Nucleated Acoustic Cavitation," Trans. Amer. Nucl. Soc., (November, 2006).
- Flanigan, D. J., and K. Suslick, "Plasma formation and temperature measurement during single-bubble cavitation," Nature, 434, March 3, 2005.
- Flynn, H., Patent US 4,333,796.
- Gross, R. A., *Fusion Energy* (John Wiley & Sons, 1984).
- Moss, W. et al., "Hydrodynamic simulations of bubble collapse and picosecond sonoluminescence," Phys.of Fluids, Vol. 6, No. 9/1994.
- Nigmatulin, R. I., R.P. Taleyarkhan and R.T. Lahey, Jr., "The evidence for nuclear emissions during acoustic cavitation revisited," J. Power and Energy **218-A**, 345 (2004).
- Nigmatulin, R. I., Iskander Sh. Akhatov, Andrew S. Topolnikov, Raisa Kh. Bolotnova, Nailya K. Vakhitova, R. T. Lahey, Jr., and R.P. Taleyarkhan, The Theory of Supercompression of vapor bubbles and nanoscale thermonuclear fusion, Phys. Fluids, Vol. 17, 107106, October, 2005.
- Putterman, S., Patent US 5 659 173A (Seth Putterman et al.) 19, August 1997.
- Taleyarkhan, R. P., and C. D. West, "Methods and Apparatus to Induce D-D and D-T Reactions," USPTO Application # 10/692,755;
- Taleyarkhan, R. P., C. D. West, J. S. Cho, R. T. Lahey,Jr., R. I. Nigmatulin and R. C. Block, "Evidence for Nuclear Emissions During Acoustic Cavitation," 295, Science, March, 2002.
- Taleyarkhan, R. P. J. S. Cho, C. D. West, R. T. Lahey, Jr., R. I. Nigmatulin, and R. C. Block., "Additional Evidence for Nuclear Emissions During Acoustic Cavitation," Phys. Rev. E., **69**, 036109, March, 2004.
- Taleyarkhan, R. P., R. T. Lahey, Jr., and R. C. Block, Ref. 32 – Science "Comments on the Shapira and Saltmarsh Report," 2002.
- Xu, Y., and A. Butt, "Confirmatory Experiments for Nuclear Emissions During Acoustic Cavitation," Nuclear Engineering and Design, 235 (2005).

Several pieces of evidence have already been published to demonstrate that the method of the present application unquestionably produces thermonuclear fusion. Such evidence has been published after time-honored worldwide peer-reviews in prestigious journals such as Science, Phys. Rev. E, Phys. Rev. Lett., Power & Energy, Nucl. Engr. and Design (Taleyarkhan et al., 2002, 2004, 2006). These observations have also been independently confirmed and published in J. Nucl. Engr. Design (Xu et al, 2005) and again in Trans. Am. Nucl. Soc, (Forringer et al, 2006), and also for scoping experiments . by Shapira/Saltmarsh in Science (Ref. 32, Taleyarkhan et al., 2002). A sound theoretical foundation has also been developed and published in the prestigious Phys. Fluids journal (Nigmatulin et al., 2005). The theoretical modeling and simulation framework has now confirmed that the experimental approach invented by Taleyarkhan would give rise to thermonuclear fusion conditions and would be energetic enough to overcome the possible endothermic reactions associated with the phenomena of dissociation and ionization. These endothermic reactions were thought of (Suslick, 2002) to be large enough to prevent attainment of plasma states, a precondition for thermonuclear conditions to take place. However, this contention has now been reversed by these same naysayers. In March, 2005 Suslick et al. published in Nature (March, 2005) for the evidence for the presence of plasmas in imploding bubbles.

Putterman et al. (2004) also published experimental evidence for 600,000 K temperatures (which are still not high-enough for attaining significant thermonuclear fusion, Gross, 1984). Importantly, temperatures in the range of 10^7K are needed. The dependence on plasma temperature during SL is known to be very steep; going from 10^6

K to 10^7 K increases the D-D nuclear fusion rate by a factor of ~ 10^9 (Gross, 1984; Nigmatulin et al., 2005). This explains the key source of difficulty for attempts made using the prior art (Crum, 1997; Didenko et al, 2002).

Ultimately, the evidence required for demonstrating the stated application method's capability to reach significant thermonuclear fusion conditions during SL is to present evidence for the presence of the tell-tale signs of thermonuclear fusion, specifically generation of 2.45 MeV neutrons and a commensurate amount of tritium. Further corroborating evidence includes, neutron emissions which should be time-correlated with the timing of SL flashes which then indicates that the process is thermonuclear in origin (i.e., hot fusion, not cold fusion). The presence of gamma rays due to neutron interaction with surrounding atoms is also useful to show. These pieces of evidence based on following the method disclosed in the present application have been published by Taleyarkhan (2004) in his second seminal paper (Phys. Rev. E, 2004). The 2004 evidence also includes experiments conducted with acoustic horns (of the type considered in the invention proposed by H. Flynn). It was also shown that the Flynn method does NOT produce tritium.

In all of the experiments where successful evidence has been produced: i.e., by Taleyarkhan et al. (2002, 2004, 2006), and separate independent experiments by Xu et al. (2005) and Forringer et al. (2006) careful experiments were conducted not just with the isotopic (e.g. deuterated) working fluids but also a series of careful control experiments without deuterated liquids – keeping all other parameters the same. The evidence for thermonuclear fusion was only obtained when the method of this present application was followed and when the liquid was isotopic (deuterated). All other control experiments

gave rise to null results. This evidence completely negates any issues related to contamination.

According to the Examiner:

> 4. The specification is objected to under 35 U.S.C. 112, first paragraph, as failing to provide an adequate written description of the invention and as failing to adequately teach how to make and/or use the invention, i.e. failing to provide an enabling disclosure.
>
> There is no reputable evidence of record to support any allegations or claims that the invention is capable of operating as indicated in the specification, that any allegations or claims of imploding a bubble that results in temperature sufficient to induce nuclear fusion reaction in a liquid or its vapor.
>
> The invention is directed to the process of producing nuclear fusion utilizing a cavitation nuclear reactor. The alleged nuclear fusion reactions are caused by the formation and collapse of bubbles by acoustic energy in a liquid. This formation and collapse of bubbles by acoustic energy is more commonly known as "sonoluminescence", "sonofusion", "acoustic inertial confinement fusion", or "sonochemistry".

Applicants respectfully disagree with the Examiner's reference to the present invention as a simple cavitation nuclear reactor since such a characterization misses and trivializes the importance of technical details related to several unique technical features characteristic of the present claimed invention. For example, degassing the working liquid to avoid or at least significantly limit gas cushioning, and timing and bombardment with fundamental particles when the working liquid is tensioned to produce a plurality of vapor bubbles from the working liquid. Evidence of operability

has already been described in detail above, including a third party 2005 paper in Physics of Fluids (Nigmatulin et al., 2005) where a sound theoretical foundation and bases that fully explain the observed experimental results (Taleyarkhan et al., 2002, 2004) as being a result of thermonuclear fusion and NOT cold fusion. The theory and simulation framework was successfully accepted after worldwide reviews in the archival literature.

According to the Examiner:

It was not until the early 1990's that sonoluminescence again surfaced in the scientific community. Scientists such as Seth Putterman and William C. Moss have stated their belief that the light generated during sonoluminescence is in the ultraviolet portion of the light spectrum. Ultraviolet light corresponds to a photon energy level of six electron volts, which is equivalent to a temperature of 72,000 °K, or 130,000 °F. Such temperatures are below the 4,000,000 °F necessary to achieve nuclear fusion. However, both Putterman and Moss believe that sonoluminescence is a viable vehicle for nuclear fusion. See for instance, Putterman, "Sonoluminescence: Sound into Light" Scientific American, 2/1995; Putterman et al (5,859,173); and Moss et al, "Hydrodynamic Situations of Bubble Collapse and Picosecond Sonoluminescence", Phys. Fluids, Vol. 6, No. 9, 9/1994.

The Examiner is provided updated results from the same Putterman (PRL, 2004) where the detected surface temperatures from a single SL bubble were recorded at the ~million K level. This refutes old arguments that temperatures during SL are only in the 10,000 K range. The original Suslick (Didenko and Suslick, 2002) reservations and

concerns related to endothermic reactions quenching the SL bubble contents to only allow ~ 10,000 K temperatures now has been also retracted by Suslick (Flanigan and Suslick, 2005) where they now accept that the SL phenomenon can indeed result in plasma states (one of the preconditions for fusion).

Applicants also provide the Examiner findings documented in the 2005 Phys. Fluids paper by Nigmatulin et al. (2005) for precisely the conditions described in the present application and related Taleyarkhan et al experiments (which are very different from the ones attainable in conventional single bubble SL bubbles like for Putterman, Suslick, Moss et al.) that temperatures in the 10-100 million K range are distinctly possible even after taking into account all dissipative processes.

According to the Examiner:

While applicant theorizes that his cavitation system according to the claimed invention can initiate nuclear fusion reactions (e.g. see page 4+ of the specification) there is no reputable evidence of record showing that the alleged evidence of nuclear fusion, e.g., generation of tritium and/or neutrons (e.g. see page 7+ of the specification)

could not actually be the result of non-nuclear (e.g., chemical) reactions or some other unknown phenomenon. Accordingly, the cavitation method for inducing nuclear reactions by bubble generation and subsequent implosion referred to in applicants specification (see page 1+), must be the result of a variation of cold nuclear fusion reactions statement is based on the fact that no indication, other than speculatio of the actual temperatures needed to achieve the nuclear reaction or the alleged generation of neutrons or tritium are provided by applicant.

Doubts have been raised by the scientific community on the generation of nuclear fusion by collapse of cavitation bubble (also referred to as "sonofusion", "acoustic ICF". "sonoluminescence". etc.). Some examples are given below.

This objection has been soundly refuted by conduct of straightforward cavitation experiments using the acoustic horn disclosed in the cited Flynn patent. The results of such experiments were shown in the inventor's 2004 Phys.Rev.E paper (Taleyarkhan et al., 2004) to NOT be able to produce tritium nor neutrons. Only if the experiments include degassing the working liquid and are conducted via synchronized fundamental particle based nucleation of bubble clusters in isotopic enriched liquids, obtaining bubbles with radius growth ratios in the range of 10,000 (versus only 10 for conventional SL expts. as proposed by Putterman, Suslick, Flynch) does one obtain 2.5 MeV neutrons and an equal quantity of tritium. Careful experiments were also conducted using normal H bearing liquids to show absence of fusion signatures.

The evidence produced by Inventor Taleyarkhan (Taleyarkhan et al., 2002, 2004) have categorically demonstrated that fusion (2.45 MeV) neutrons are emitted at the same time level as the SL light flashes which demonstrate that the conditions in the imploding bubbles is HOT. The experiment procedure method was simulated theoretically (Nigmatulin et al, 2005) and the physics of implosion under this method was shown to be adequate to produce ~ 10^6 n/s and or 10^6 tritium atoms /s and that the fusion products are emitted when the bubbles have imploded and produced hot (~ 10^8K) plasma states. Therefore, experimentally and with a theoretical foundation both accepted in the archival literature in the most strict oversight medium for acceptance in the world, the unique approach/method of the present invention has been accepted by technical experts that this is HOT thermonuclear fusion. Cold fusion on the other hand has relied on increasing the density of D atoms in Pd like metals at room temperature like conditions. Also, no systematic data have ever been produced for 2.45 MeV neutrons, tritium and gamma rays – unlike the evidence presented by the inventor (Taleyarkhan, 2002, 2004, 2005, 2006).

According to the Examiner:

> **L.Crum, in his paper, "Sonoluminescence and Acoustic Inertial Confinement Fusion" presented at the "Fifth International Symposium on Cavitation," Osaka, Japan, Nov. 1-4, 2003, reports the following issues:**
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> - **The temperature required for significant D-D fusion is in the order of 100 million degrees. Temperature within a sonoluminescing bubble did not exceed a few tens of thousands of degrees. See page 1, col. 2, 2nd paragraph).**

As described above, this is an observation made by L. Crum based on his assessment of what the worldwide researchers had produced as evidence for a single standing bubble undergoing SL, NOT for bubble clusters that are nucleated by

fundamental particles (e.g. neutrons or alphas) using the method of the present invention. The argument is simply not relevant to the method of described in the present application.

According to the Examiner:

- **Seth Putterman, proponent for Acoustic ICF, reports he has been unsuccessful in detecting any neutrons that were coincident with sonoluminescence during cavitation collapse. See page 2, col. 1, 3rd full paragraph).**
- **Ken Suslick, University of Illinois, noted that atomic and molecular dissociation and ionization were difficult barriers to breach because they required lots of energy, indication that several liquids would not be suitable for generating acoustic ICF. He further indicated that the role of vapor in preventing the heating of fusion plasma must be carefully considered. Based on his own data using a variety of molecular liquids, he suggested that temperatures of only 7,000-10,000degerees are much more likely, contrary to the claims of temperature in the millions of degrees. See page 2, col. 2, 2nd paragraph.**

Applicants note that Putterman's cited system in Crum's paper (2003) is a single SL bubble system of prior art (1997), not of the type described in the present application. Significantly, Suslick has now publicly retracted his published statement made per his state of knowledge and understanding in 2002; see his 2005 Nature paper (Flanigan and Suslick, 2005) where he now clearly accepts the formation of plasmas using SL, one of the preconditions for thermal fusion which he was earlier in 2002 claiming could simply not happen. It is true that significant endothermic reactions can prevent high temperature (tens of millions of K) plasma for a single gas-filled SL bubble as in Suslick or Putterman's or Moss's systems, but these loss mechanisms are a ~1% type effect and not capable of preventing the condensing vapor bubble system of Taleyarkhan et al due to the vastly higher reservoir of potential energy (see explanation in 2005 Phys.Fluids paper by Nigmatulin, Taleyarkhan et al.). This line of technical basis has been vetted by recognized experts in the field due to which the theory and simulation work has been

granted acceptance and published for archival purposes in the Phys. Fluids Journal (Nigmatulin et al., 2005).

According to the Examiner:

- "D. Shapira and M. Saltmarsh, Oak Ridge National Laboratory, failed to reproduce the results of Taleyarkhan experiment to produce thermonuclear fusion from cavitating bubbles. The duo, using a different neutron-gamma

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detection system found that the excess neutrons they detected with cavitation on (versus cavitation off) were lower than one would expect from the reported tritium data by Taleyarkhan. Shapira pointed out that the "excess" neutrons attributed by Taleyarkhan to acoustic ICF probably came from the pulsed neutron generator used in the Taleyarkhan experiment. See page 3, col. 1, 2nd paragraph.

Applicants respectfully submit that the above assertions are incorrect. The Examiner has only cited an earlier piece of work by Shapira and Saltmarsh who had incorrectly calibrated their instruments. It is important to recognize that Shapira and Saltmarsh also produced evidence of excess nuclear emissions. The main issue for their report was in terms of the level of emission as not being similar to what Taleyarkhan et al. (2002) reported for tritium and, not whether statistically excess nuclear emissions were indeed detected (which they were). See recorded revised analysis of this work - documented as Ref. 32 in 2002 Science paper by Taleyarkhan et al. (2002) and later in J.Power and Energy (Nigmatulin et al., 2004). It is further noted that Shapira/Saltmarsh did not measure for tritium in the experiments they monitored at Oak Ridge, only neutrons which they did measure and publicly accept as the examiner has pointed out also. It is to be realized that every new experiment does not result in the same quantity of

neutron emission as past experiments - the output can vary significantly due to the steep exponential dependence of fusion rates on plasma temperatures as already mentioned in the 2004 Phys.Rev.E paper by Taleyarkhan et al.

According to the Examiner:

> **I. Sample, "The Guardian", March 2004, reports in the article, "Science runs into trouble with bubbles" that:**
>
> - **Reviewers of Taleyarkhan's paper on his experiment dismissed the claim of tritium production on the ground that his laboratory was probably contaminated by that element.**

Applicants respectfully note that the above is a red-herring being an issue brought up likely in desperation by well-known competitors (Putterman and Suslick) of the present Inventors, and thus without any merit. As publicly announced (Taleyarkhan et al., 2002, 2004) experiments were conducted not just with D-bearing working fluids as described in the present application, but with corresponding control experiments conducted also with the normal H-bearing liquids – all else being kept the same. If the laboratory was contaminated by tritium then the contamination should have affected the D-atom based fusion experiments in the same manner as for all of the number of control cases in H-atom bearing experiments. Excess tritium was only produced when the experiments were conducted with D-atom bearing liquids. Also, the experiments series were conducted to monitor for 2.45 MeV neutrons, gamma rays. Neutrons, Tritium and Gamma rays were all ONLY produced for experiments with D-atom bearing liquids using the method of this invention. Never, otherwise. Therefore, the issue of contamination of tritium by itself is completely unfounded and without any merit.

According to the Examiner:

> Gordon Pusch (http://www/physics-talk.com/Why-is-acetone-used-in-sonofusion-experiments-6987552.html) writes the following observations:
>
> - On the issue of how Taleyarkhan would infer that his apparatus is generating millions of K, Pusch indicates that critics of the "hydrodynamic" computer model of the bubble implosion argue that the model neglects the physical limitations imposed by molecular dynamics degrees of freedom.

All such theoretical issues were convincingly considered and put to rest during the international peer reviews by anonymous technical experts worldwide prior to acceptance for publication in the prestigious Phys. Fluids journal (Nigmatulin et al., 2005). All issues related to all known endothermic reactions such as dissociation and ionization which can prevent high temperatures (to the tens of millions K) to be reached were meticulously included during the hydrocode simulations as detailed in a far more extensive paper reviewed by worldwide experts and archived in the prestigious 2005 Phys.Fluids journal (Nigmatulin, Taleyarkhan et al).

According to the Examiner:

> - As to the tritium detected in the chamber, Pusch thinks that it might have been produced by neutron capture on deuterium, since the chamber was "degassed" by acoustically cavitating it under neutron bombardment for approx. 2 hours before experimental runs were performed.

Applicants respectfully note that the above is impossible since control experiments were conducted with the same deuterium bearing liquid and incident neutrons but with bubble production turned OFF (by a slight phase shift in the drive frequency of the acoustic system by about << 1%) all else being kept the same including

the external neutron source. No tritium was detected in these control experiments. This has been categorically demonstrated and presented in the extensively peer-reviewed manuscripts in Science, Phys. Rev. E journals(Taleyarkhan et al., 2002, 2004). Furthermore, it is straightforward to prove with a simple hand calculation that it is simply impossible to transmute sufficient D-atoms to T to produce a noticeable signature (i.e., this possible effect is x 1,000 smaller than the rate of tritium measured when bubbles were formed and when they imploded using the method taught in this invention).

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- **Sonoluminescence results from a tiny jet of liquid that shoots across the inside of the bubble, and because of the complex interplay between the buoyancy of the bubble and the sound field, the fluid is forced to push out a finger of water from the bubble's surface, i.e., "hammer of water."**
- **Bubble temperatures in sonoluminescence would peak at 10,000 °F, which is enough to explain chemical activity, but far below the amount needed to produce nuclear fusion.**

Applicants respectfully note that the above theory has been soundly rejected along with several others such as fractoluminescence. That SL is generated due to shock heating of a plasma is now unrefuted (Crum, 1997; 2003).

According to the Examiner:

Nuclear News, in its September 2002 article, "Chemistry casts doubt on bubble fusion", has the following statement:

> - Scientists at the University of Illinois at Urbana-Champaign (UIUC) have determined that fusion is unlikely to occur in volatile liquids such as water or acetone, which was used in the original bubble experiment.
>
> (Examiner's note: Applicant's claimed invention uses deuterated acetone as working liquid (e.g., see claim 33)

Applicants respectfully note as noted above the theoretical foundations for the contrary are described in the comprehensive paper "Theory of Supercompression in Deuterated Acetone" by Nigmatulin et al, 2005 Phys.Fluids. Univ. Illinois scientists missed several important physics-based attributes which clarify why to the contrary organic liquids such as acetone is a good liquid for fusion induction due to possessing very high (~1) accommodation coefficients whereas, inorganic liquids such as water are not good (coeff. <<1). Indeed this was one of the key reasons for choosing degassed isotopic (deuterated) organic liquid rather than follow conventional approaches that were based on inorganic liquids.

Indeed, the choice of an organic liquid, such as acetone, which cited art considered to be NOT appropriate per the examiner's citation, is exactly what this invention propounds. High molecular weight organic liquids like acetone which have high vs. low accommodation coefficients and which are amenable to large tension capability is why such liquids were used in the first place and constitute one of several key distinguishing factors in favor of this present application compared with prior art (organic liquid recited in new claim 43).

According to the Examiner:

Applicant's invention is considered to be nothing more than a variation of the "cold fusion" system/concept set forth by Fleischmann and Pons (see the 3/24/89 article by D. Braaten). Note further, that merely proposing a new or different theory to account for the alleged production of nuclear reaction products does not change such systems into non-cold fusion systems.

Applicants respectfully note that nothing could be further from the opposite. In cold fusion experiments the neutron emission rate has been noted to be a million times smaller than that for tritium. In nuclear particle induced bubble fusion the neutron and tritium production rates are close to 1:1. Also, during experiments based on the present invention, the neutron emissions occur together with the SL light emission time period clearly indicating that the nuclear emissions occur when conditions in the bubble clusters are extremely hot and highly compressed.

According to the Examiner:

Many laboratories have attempted to confirm nuclear reactions taking place during sonoluminescence. The results of these attempts at confirmation have been primarily negative (see for example, Kaiser, "Inferno in a Bubble Turning sound into light poses a tantalizing puzzle" Science News, Vol. 147, 4/1995).

Applicants respectfully note that the above reference has no meaningful relation to the present claimed invention. The Kaiser work relates to conventional single gas bubble SL. This paper along with most others cited in the objection by the examiner predates the discovery of Taleyarkhan et al. upon which the present application is based.

According to the Examiner:

> Moss further asserts that even if nuclear fusion by sonoluminescence is possible it will not be capable of use as an energy source. To quote, "If I were to tile the world with these SL devices, throw all the people off to make more room, and they generated thermonuclear fusion for 1 hour, all the energy put together would be enough to heat a cup of water one degree.". See "Star in a Jar", Popular Science, 12/1998.

Applicants respectfully note that Moss's assertions are based on conventional single bubble SL experimentation (as patented by Putterman, 1999). The fusion rate from such a bubble system is assessed to be more than billion to trillion (10^9 to 10^{12}) of times smaller than from a corresponding system developed by Taleyarkhan et al., the subject of this present invention. This aspect has been amply clarified already (Nigmatulin et al., 2005) and is explained in the 2002 Science paper supplement by Taleyarkhan et al and furthermore, in 2005 Phys.Fluids paper by Nigmatulin et al. (2005). When multiplied by a billion to a trillion times, the simplistic argument made by Moss takes on a completely new dimension in terms of its potential for heating fluids.

According to the Examiner:

Applicant's specification contains assumptions and speculation as to how and in what manner, his invention will operate (see specification page 1+). Indeed, applicant appears to be basing the operativeness of his invention on various approximations, estimations, assumptions, etc., of the specification. It can be said that one could manipulate any number of approximations, estimations and assumptions to come up with a result which would allegedly "work" in theory. However, applicant has presented no reputable factual evidence to support his assumptions and speculation, that his invention is operative. Without reputable evidence to the contrary, the accepted scientific community theory is presumed correct (i.e., no nuclear reactions are taking place disclosure is insufficient in failing to set forth the underlying assumptions for

As described above, more than ample, factual evidence for the operative aspect of the method of the invention has been provided. Two of the world's most prestigious journals, Science (2002) and Phys.Rev.E (2004), have vetted the experimental (operative) work based on the present application and the data after intense worldwide reviews from recognized experts. The theoretical foundations supporting the understanding of why and how the claimed method works has also been vetted for thoroughness and sound technical bases by the strictest of in-depth reviews. These are the time-honored pillars of the foundations of the inventors' technical work for judging on the validity of technical claims. Detailed evidence has been presented with unambiguous statistical significance of over 20 standard deviations (Taleyarkhan et al., 2004). Usually 4 standard deviation of statistical significance is considered adequate to prove that a physical process is factual and operative. Having more than 10 standard deviations means a virtual and complete unambiguous certainty for the operative nature of the claimed fusion process.

According to the Examiner:

> The specification appears to refer to tests and experiments wherein nuclear reaction products, e.g., tritium and neutrons, have been produced (see pages 62+). However, these indications or allegations are not sufficient to overcome the numerous teachings by skilled artisans, (set forth above by the examiner) that the allegations of the obtainment of said nuclear reactions or products in such a system are not reproducible or even obtainable. It is not clear from the information set forth in the specification, that when all possible sources of error are taken into account, that the applicant would still be able to show positive results or that the alleged positive results do not fall within the limits of experimental error or, that the alleged positive results are no more than a misinterpretation of experimental data. For example, since applicant's invention is closely related to or a variation of the concept of "cold fusion" a study in the source of errors in such systems is appropriate and applicable (see for example Browne, Kreysa et al, Lewis et al, Hilts, Horanyi, Ohashi et al, MisKelly et al, Stipp or Chapline).

Applicants note that possible experimental errors have been soundly accounted for via:

1) Conduct of control experiments; -for every experiment conducted with deuterated cavitated liquid where nucleation is done via nuclear particles a corresponding experiment was also conducted with non-deuterated liquid.

2) Investigation of statistics indicates that the neutron and tritium emissions are obtained with >>99.9999999...% significance. Emissions of neutrons for example are found to be > 100% over the background of neutrons from a pulsed neutron generator where the experimental deviation over time is found to be < 1%.

3) As explained above, with the data for neutrons being over 20 standard deviations in statistical significance, any error related question is absolutely a non-issue. The data literally "grow" in front of one's eyes as has been amply demonstrated (see for example Fig. 7 -Taleyarkhan et al., 2004)

According to the Examiner:

> to indicate applicant has so succeeded where others have failed, in arriving at an operative sonoluminescent system, i.e. that he has progressed his system beyond the point of an unproven theory or concept which still requires an undue amount of
>
> It is thus considered that the examiner (for the reasons set forth above) has set forth a reasonable and sufficient basis for challenging the adequacy of the disclosure. The statute requires the applicant itself to inform, not to direct others to find out for themselves; In re Gardner et al, 166 U.S.P.Q. 138, In re Scarbrough, 182 U.S.P.Q. 2[illegible] Note that the disclosure must enable a person skilled in the art to practice the invention without having to design structure not shown to be readily available in the art; In re Hirsch, 131 U.S.P.Q. 198.

Applicants again take the opportunity to clarify. The present application has indeed provided detailed drawings of the actual apparatus successfully used for the experiments for which the data were presented (Se also Taleyarkhan et al., 2002, 2004). All the components, the material composition and details on how the various system components such as the PZT piezoelectric elements are to be attached and with what specific epoxy substance, how the filtration was done, how the degassing was

accomplished using acoustic agitation with and without neutrons, the timing of neutrons with acoustic tension, the temperature of the environment system, the level of drive power, the possible nucleation methods, their timing, the approach for tensioning, etc.

According to the Examiner:

5. Claims 22-25 and 27-33 are rejected under 35 U.S.C. 101 because the claimed invention as disclosed is inoperative and therefore lacks utility.

The reasons that the inventions as disclosed is inoperative are the same as the reasons set forth in section 4 above as to why the specification is objected to and the reasons set forth in section 4 above are accordingly incorporated herein.

There is no reputable evidence of record to indicate the invention has been reduced to the point of providing in current available form, an operative nuclear system (including one that generates nuclear fusion and reaction products). The invention is not considered as meeting the requirements of 35 U.S.C. 101 as being "useful". Note in this respect," Star in a Jar", Popular Science, 12/1998 which indicates that there is no convincing evidence that the phenomena attributed to sonoluminescence would produce useful sources of energy.

The applicant at best, has set forth what may be considered a concept or an object of scientific research. However, it has been held that such does not present a utility within the meaning of 35 U.S.C. 101. See Brenner v. Manson, 148 U.S.P.Q. 689.

Applicants respectfully note that the examiner is misguided in his conclusions drawn from the cited paper based on numerical calculations by W. Moss who performed his assessments for the single-bubble SL based system representing prior art for which we agree that utility for that approach would be highly limited.

However, as described above, far from being a mere concept, the world has now experienced in top-quality, via published peer-reviewed journal articles (Taleyarkhan et

al., 2004, Nigmatulin et al., 2005) that the method of the present invention provides fusion output levels that are a billion to trillion (10^9 to 10^{12}) times higher than at all possible using prior art methods as utilized by W. Moss in his 1998 paper. Therefore, not only is there published irrefutable operative evidence in the archival literature (Taleyarkhan et al., 2002, 2004, 2006; Nigmatulin et al., 2005), the inventive method has also now been confirmed by others since 2002 (Xu et al., 2005, Forringer et al., 2006).

Regarding utility, Applicants note that even without break-even energy production, the very possibility for creating significant thermonuclear fusion rates in the 10^6 n/s or T/s has multifarous and immediate utility in terms of: (1) providing a pulsed fast neutron source which otherwise requires $100K+ accelerator based systems; (2) method to produce tritium which has numerous uses; (3) facility to create intensely strong compressions and high temperatures that then become suitable for studying things like imploding thermonuclear devices on the microscale; and, (4) a pathway for scaling upwards towards possible net energy generation.

According to the Examiner:

6. Claims 22-25 and 27-33 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. The reasons that the inventions as disclosed are not enabling are the same as the reasons set forth in section 4 above as to why the specification is objected to and the reasons set forth in section 4 above are accordingly incorporated herein.

Design drawings and details of setup and operation have been provided already to permit one having ordinary skilled in the art to make and use the present invention without undue experimentation. As described above, the method of the present application has been successfully used and publicly demonstrated in published works in the archival literature via the Nuclear Engr. and Design Journal and Trans. American Nuclear Society (Xu et al, 2005; Forringer et al., 2006).

Accordingly, in light of the above description and references provided in support thereof, the present claimed invention based on the present application satisfies 35 USC 112, as well as 35 USC 101.

Turning now to cited art, according to the Examiner:

8. Claims 22, 23, 27 and 28 are rejected under 35 U.S.C. 102(b) as being anticipated by either one of Putterman et al. (U.S. 5,659,173) or Flynn(U.S. 4,333,796).

Either one of Putterman et al. or Flynn disclose a method for producing nuclear fusion using acoustical waves to cause implosion of a liquid containing hydrogen isotopes (e.g., see Abstract in Putterman or col. 1, lines 20+ in Flynn).

As to the claim limitation regarding nuclear particles cavitating the tensioned liquid, either one of Putterman et al. or Flynn inherently meets this limitation because their system includes nuclear particles such as deuterium or tritium that have not interacted with other particles and therefore inherently available for cavitation.

Flynn is entitled "Method of generating energy by acoustically induced cavitation fusion and reactor therefrom" and discloses two different cavitation fusion reactors (CFR's). Each comprises a chamber containing a liquid (host) metal such as lithium or an alloy thereof. Acoustical horns in the chamber walls operate to vary the ambient pressure in the liquid metal, creating therein small bubbles which are caused to grow to maximum sizes and then collapse violently in two steps. In the first stage the bubble contents remain at the temperature of the host liquid, but in the second stage the increasing speed of collapse causes an adiabatic compression of the bubble contents, and of the thin shell of liquid surrounding the bubble. Application of a positive pressure on the bubble accelerates this adiabatic stage, and causes the bubble to contract to smaller radius, thus increasing maximum temperatures and pressures reached within the bubble. At or near its minimum radius the bubble generates a very intense shock wave, creating high pressures and temperatures in the host liquid. These extremely high pressures and temperatures occur both within the bubbles and in the host liquid, and cause hydrogen isotopes in the bubbles and liquid to undergo thermonuclear reactions. In one type of CFR the

thermonuclear reaction is generated by cavitation within the liquid metal itself, and in the other type the reaction takes place primarily within the bubbles. The fusion reactions generate energy that is absorbed as heat by the liquid metal, and this heat is removed from the liquid by conduction through the acoustical horns to an external heat exchanger, without any pumping of the liquid metal.

Flynn's method is thus based on a vessel filled with gaseous isotopically enriched liquid that is agitated using ultrasonic horns which randomly nucleate bubbles. Flynn hypothesized (just like Putterman -1997, without providing any experimental evidence for operability) that the SL producing bubbles "may" become hot enough to produce the tell-tale signs of thermonuclear fusion, viz., 2.45 MeV neutrons and tritium.

Flynn's method has little relevance to the claimed invention since Flynn does not disclose or suggest any of the following claimed steps:

"degassing said liquid to reduce a dissolved gas content therein, wherein said dissolved gas is removed using an applied vacuum" or

"directing fundamental particles at said liquid portion when said liquid portion is in said tension state, said fundamental particles having sufficient energy for nucleating a plurality of bubbles from said liquid".

Applicants note that the deuterium or tritium disclosed by Flynn is clearly not the claimed fundamental particles which as noted above are well known in the art to be particles which make up the nuclei of all atoms, such as neutrons and alpha particles , nor do they have sufficient energy to cause nucleation since they have only their thermal energy (about 0.01 eV). There is no means provided to accelerate them from their energy at ambient temperature (about 0.01 eV) to the approximate minimum levels of about

Million eV (1 MeV) required for the nucleation of critical size vapor bubbles to take place and that too only when the liquid is tensioned metastable pressure state. Accordingly, the claimed invention recited in new claim 34 and its respective dependent claims are patentable over Flynn.

Putterman is entitled "Converting acoustic energy into useful other energy forms" and discloses sonoluminescence is an off-equilibrium phenomenon in which the energy of a resonant sound wave in a liquid is highly concentrated so as to generate flashes of light. The conversion of sound to light represents an energy amplification of eleven orders of magnitude. The flashes which occur once per cycle of the audible or ultrasonic sound fields can be comprised of over one million photons and last for less 100 picoseconds. The emission displays a clocklike synchronicity; the jitter in time between consecutive flashes is less than fifty picoseconds. The emission is blue to the eye and has a broadband spectrum increasing from 700 nanometers to 200 nanometers. The peak power is about 100 milliWatts. The initial stage of the energy focusing is effected by the nonlinear oscillations of a gas bubble trapped in the liquid. For sufficiently high drive pressures an imploding shock wave is launched into the gas by the collapsing bubble. The reflection of the shock from its focal point results in high temperatures and pressures. The sonoluminescence light emission can be sustained by sensing a characteristic of the emission and feeding back changes into the driving mechanism. The liquid is in a sealed container and the seeding of the gas bubble is effected by locally heating the liquid after sealing the container. Different energy forms than light can be obtained from the converted acoustic energy. When the gas contains deuterium and tritium there is the

feasibility of the other energy form being fusion, namely including the generation of neutrons.

Putterman discloses apparatus with a preset "single" levitated "gas" (not vapor from the working liquid) bubble that is periodically (continuously) expanded by factors of ~ 10 from the initial radius and imploded back. Putterman hypothesized without any experimental evidence that if the implosion can be made robust enough, a shock wave can be launched and flashes of sonoluminescence (SL) light are produced. Furthermore, Putterman hypothesizes (without showing experimental proof of operability, i.e., via measurement of neutrons and tritium) that if the plasma is hot and compressed enough, then nuclear fusion may be made to occur to produce the tell-tale signs of thermonuclear fusion (2.45 MeV neutrons and tritium).

Putterman is cited for an alleged teaching of degassing. However, Putterman cannot degass since Putterman requires a gas bubble to be present in the liquid, which means a gassy liquid is a precondition for their method which relies on rectified diffusion to attain SL. In such an apparatus, gas in the liquid is always required for it to function. Otherwise, in a totally degassed liquid a gas bubble can neither be generated using the hot-wire approach of Putterman et al. (1997) and also not remain if injected – because by the laws of partial pressures the gas/it has to go back into the liquid solution. The shortcoming is also found in Flynn. In contrast, the claimed invention degasses under vacuum so that the working liquid is essentially bubble free prior to irradiation with fundamental particles, so that the bubbles used are vapor from the working isotopic liquid, not generally ambient gas bubbles in the working liquid.

Thus, although having more relevance than Flynn's method to the claimed invention, Putterman's single standing bubble filled with gas in inorganic liquid process does not disclose or suggest any of the following claimed steps:

"degassing said liquid to reduce a dissolved gas content therein, wherein said dissolved gas is removed using an applied vacuum" or

"directing fundamental particles at said liquid portion when said liquid portion is in said tension state, said fundamental particles having sufficient energy for nucleating a plurality of bubbles from said liquid".

Applicants note that like Flynn, the deuterium or tritium disclosed by Putterman are clearly not the claimed fundamental particles which are well known in the art to be particles which make up the nuclei of all atoms, such as neutrons and alpha particles, nor do they have sufficient energy to cause nucleation since they have only their thermal energy (about 0.01 eV). Again, like Flynn, in Putterman there is no means provided to accelerate them from their energy at ambient temperature (about 0.01 eV) to the approximate minimum levels of about Million eV (1 MeV) required for the nucleation of critical size vapor bubbles to take place and that too only when the liquid is tensioned metastable pressure state. Accordingly, the claimed invention recited in amended claim 34 and its respective dependent claims are patentable over Putterman.

Applicants believe the present application is in condition for allowance. Should the Examiner feel otherwise, Applicants request the Examiner to call the undersigned before issuance of any office action to set up a telephonic interview to expedite the prosecution of the present application to an allowance.

No fees are believed due with this request, however the Commissioner for Patents is hereby authorized to charge any deficiency in fees due with the filing of this document and during prosecution of this application to Deposit Account No. 50-0951.

Respectfully submitted,

AKERMAN SENTERFITT

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Neil R. Jetter, Registration No. 46,803
AKERMAN SENTERFITT
P.O. Box 3188
West Palm Beach, FL 33402-3188
Tel: 561-653-5000

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